

CLAIMS

What is claimed is:

1. In a data communications system using a power feeding arrangement with a coupling transformer having an equipment side winding and a line side winding, an apparatus for reducing signal distortion caused by a flux imbalance associated with the transformer comprising:

a. a distortion monitoring circuit having a monitoring input coupled to the equipment side winding of the coupling transformer and operative to generate at an error output an error signal corresponding to measurements of the signal distortion sampled by the monitoring circuit;

b. a flux controller having a control input in electrical communication with the error output of the distortion monitoring circuit and operative to generate at a control output a flux cancellation signal in response to the error signal; and

c. a flux generator having a first generator input in electrical communication with the control output of the flux controller and a generator output in electrical communication with the equipment side winding of the coupling transformer, the flux generator responsive to the flux cancellation signal to generate a cancellation flux to reduce the flux imbalance.

2. The apparatus of Claim 1 wherein the distortion monitoring circuit comprises an echo canceller.

3. The apparatus of Claim 1 wherein the distortion monitoring circuit further comprises an equalizer circuit electrically connected between the echo canceller and the control input.

4. The apparatus of Claim 2 wherein the echo canceller comprises a
5 combination of an analog echo canceller, an analog to digital converter, and a digital echo canceller operatively connected in logical sequence between the equipment side winding of the coupling transformer and the control input of the flux controller.

5. The apparatus of Claim 1 wherein the flux generator comprises a signal summer having a second input connected to a transmit signal.

6. The apparatus of Claim 5 wherein the signal summer is a digital summer
10 and the flux generator further comprises a digital to analog converter connected between the digital summer and an analog filter.

7. The apparatus of Claim 6 wherein the flux generator further comprises a line
15 driver circuit operatively connected between the analog filter and the equipment side winding of the coupling transformer.

8. The apparatus of Claim 7 wherein the line driver circuit comprises an amplifier.

9. The apparatus of Claim 1 wherein the distortion monitoring circuit and flux
20 controller are operative to measure a plurality of samples of the signal distortion and to vary the error signal and flux cancellation signal in response to measured changes in the samples of the distortion signal.

10. A flux imbalance compensator for a data communication system having a transmit signal and a coupling transformer with an associated flux imbalance, the compensator comprising:

a. a signal quality monitor circuit electrically connected to the transformer and operative to detect the flux imbalance associated with the transformer and to generate a detected quality signal;

b. a flux cancellation signal generator electrically connected to the signal quality monitor circuit and operative to receive the detected quality signal and generate a flux cancellation signal in response thereto;

c. a signal summer for generating a transformer signal by combining the input data signal and the flux cancellation signal; and

d. a line driver circuit coupled to the transformer for receiving the transformer signal and generating a cancellation flux to reduce the flux imbalance.

11. The flux imbalance compensator of Claim 10, the line driver circuit comprising an amplifier connected between the signal summer and the flux generator for amplifying the transformer signal.

12. The flux imbalance compensator of Claim 10 further comprising an analog filter operatively connected between the signal summer and the line driver circuit.

13. The flux imbalance compensator of Claim 10, the signal quality monitor including an analog canceller.

14. The flux imbalance compensator of Claim 10 wherein:

a. the transmitter signal comprises a digital transmit signal;

b. the signal summer includes a digital signal summer for receiving and combining a digital cancellation signal and the digital transmit signal to create a combined digital signal, and a digital to analog converter to convert the combined digital signal into the transformer signal;

5 c. the signal quality monitor includes an analog to digital converter connected to a digital echo canceller and operative to convert the transformer signal from analog to digital format, the digital echo canceller also connected to the digital input data signal, wherein the signal quality monitor monitors the transformer signal and the digital transmit signal to produce the detected quality signal including a digital detected quality signal as an output of the digital echo canceller; 10 and

d. the cancellation signal generator processes the digital detected quality signal to generate the cancellation signal including the digital cancellation signal.

15 ~~15.~~ A circuit associated with a data transmission system for reducing a flux imbalance associated with a transmit signal sent through a power feeding transformer comprising: 15

a. an echo canceller for generating a canceller error signal;

b. a flux controller in electrical communication with the echo canceller and operative to monitor the canceller error signal and to generate a responsive flux 20 canceller signal;

c. a signal combiner for summing the transmit signal with the flux canceller signal to form a transformer input signal; and

d. a winding in the transformer for receiving the transformer input signal and generating a flux to reduce the flux imbalance.

16. The circuit of Claim 15 further comprising a signal amplifier electrically connected between the signal combiner and the winding.

5 17. The circuit of Claim 16 further comprising an analog filter electrically connected between the signal combiner and the signal amplifier.

18. The circuit of Claim 17 further comprising a digital to analog converter electrically connected between the analog filter and the signal combiner.

19. The circuit of Claim 15, the echo canceller including an analog echo canceller.

10 20. The circuit of Claim 19, the echo canceller further including an analog to digital converter electrically connected to an output of the analog echo canceller and a digital echo canceller electrically connected an output of the analog to digital converter.

15 21. The circuit Claim 15 wherein the echo canceller includes a digital echo canceller.

~~22.~~ A device for reducing an unwanted flux in a duplex data transmission system sending a digital transmit signal having a near end signal and a far end signal through a transformer comprising:

20 a. a digital summer for combining a digital flux cancellation signal with the digital transmit signal to form a digital combination output signal;

b. a digital to analog converter for converting the digital combination output signal into an analog combination output signal;

c. a line driver circuit for powering transmission of the analog combination output signal through the transformer and thereby generating a flux to offset the unwanted flux and receiving a return signal including a flux from the transformer;

5 d. an echo canceller for canceling the near-end signal so that only the far-end signal remains, the echo canceller including an analog echo canceller connected to a digital echo canceller through an analog to digital converter, the digital echo canceller operative to generate a digital error signal;

10 e. an equalizer for separating the far end signal from the digital error signal; and

f. a flux controller for receiving the digital error signal and generating the digital flux cancellation signal.

23. A method for reducing distortion associated with a flux imbalance in a coupling transformer used in a power feeding arrangement for a data communication system, the method comprising the steps of:

15 a. measuring the distortion to obtain an error signal;

b. generating a flux cancellation signal from the error signal;

c. using the flux cancellation signal to generate a compensating flux signal; and

20 d. applying the compensating flux signal to the transformer to reduce the flux imbalance.

24. A method for offsetting an undesired signal in a data transmission system sending a digital transmit signal through a transformer comprising:

- a. setting a flux canceller signal to an initial value;
- b. obtaining a first measurement of the undesired signal in the
5 transformer;
- c. making a first adjustment of the flux canceller signal from the initial value according to the first measurement of the undesired signal;
- d. generating a flux offset signal in response to the first adjustment of the flux canceller signal;
- e. combining the flux offset signal with the digital transmit signal;
- f. obtaining a second measurement of the undesired signal and
10 comparing the second measurement with the first measurement; and
- g. making a second adjustment of the flux canceller signal in accordance with the comparison between the first and second measurements of the undesired
15 signal.

25. A method for multiple signal adjustment to offset an undesired signal in a data transmission system sending a transmit signal through a power feeding transformer comprising:

- a. initializing a flux canceller signal value;
- 20 b. measuring a signal quality to determine properties of the undesired signal;

c. modifying the flux canceller signal value in accordance with the measurement of the signal quality;

d. generating an offset flux in accordance with modification of the flux canceller signal value;

5 e. combining the offset flux with the transmit signal; and

f. repeating the steps of measuring, modifying, generating, and combining until the measured signal quality reaches a pre-determined threshold.

26. In a simplex power arrangement of a data communications system having a transceiver with a transmit signal and further having an echo canceller providing an error signal responsive to nonlinearities caused by flux imbalance in a coupling transformer, an apparatus comprising:

a. a flux controller for generating a flux canceller signal in response to the error signal and in accordance with a flux cancellation algorithm;

b. a signal summer for combining the transmit signal and the flux canceller signal; and

c. an amplifier coupled to the summer, the amplifier providing an output signal to a winding on a transceiver side of the transformer.

27. In a simplex power arrangement of a data communications system having a transceiver generating a transmit signal and further having an echo canceller having an error signal responsive to flux imbalances associated with a coupling transformer in the system, a method for canceling signal nonlinearities caused by the flux imbalances comprising the steps of:

a. measuring the error signal;

b. adjusting a flux canceller signal to a new value based on the measurement of the error signal;

c. re-measuring the error signal; and

5 d. readjusting the flux canceller signal in accordance with a flux cancellation algorithm.